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September 14, 2001

Mr. Lake H. Barrett, Acting Director
OCRWM
Department of Energy
Washington, DC 20585

Dear Mr. Barrett:

Thank you for your letter of August 28, 2001 with its invitation for comments on the Yucca Mountain project. I am happy to respond, because of the importance of the issues.

To identify myself briefly: I am a Professor Emeritus of Physics at the University of Washington, where I have been a faculty member since 1954 and served as Department Chairman from 1976 to 1984. I have long been interested in energy matters and authored *Nuclear Energy: Principles, Practices, and Prospects* (American Institute of Physics Press/ Springer-Verlag, 1996).

This letter has three parts:

A. A brief summary.
B. A response to the specific topics raised in your letter.
C. General comments on the broader issues.

A. SUMMARY

I think the Yucca Mountain process should move ahead without excessive delay. Very rigorous radiation protection standards have been established by the EPA for Yucca Mountain, and the OCRWM studies to date indicate that these standards will be satisfied by a wide margin. Therefore I believe the President and Congress should act to enable the DOE to apply for authorization from the NRC to construct the Yucca Mountain repository.

Some issues still must be addressed, in particular the questions raised by the NWTRB on waste package corrosion resistance and by staff of the NRC on volcanic hazards. It is my understanding that these issues are being actively pursued by the OCRWM, and it appears to me probable that they will be satisfactorily resolved. Hence, I think it prudent to take the intermediate step of seeking construction authorization.

Any small risks of establishing the repository must be compared to the risks of trying to do without it. The abandonment of Yucca Mountain would mean, at the very least, a long delay in the further development of U.S. nuclear power. In my mind, the risks this would create are more immediate and involve greater potential dangers than any that now appear plausible for a Yucca Mountain repository.

B. RESPONSES TO SPECIFIC TOPICS SUGGESTED BY MR. BARRETT.

Topic 1. The PSSE follows upon a long series of studies sponsored or carried out by the DOE, including a succession of Total System Performance Assessments and numerous supporting technical documents and extensive summaries. Positive conclusions as to the overall safety of the proposed repository are contained in a series of analyses by the Electric Power Research Institute, including its *Evaluation of the Candidate High-Level Radioactive Waste Repository at Yucca Mountain, using Total System Performance Assessment, Phase 5* (November 2000). Of course, it is impossible for an independent individual to critically analyze all the technical details. However, it is reassuring to note that these very extensive arrays of studies have drawn upon scientists at a wide variety of institutions and that current design plans are the result of an iterative, evolutionary process that afforded numerous opportunities for uncovering omissions or errors.

One of the strengths of the present process has been the opportunity it has provided for a wide range of independent reviews and analyses. These reviews have brought out two issues that it is important for the OCRWM to address further, both in analyses and in public documents.

The first of these is the concern expressed by the Nuclear Waste Technical Review Board (April 2001) on the corrosion resistance of the waste package. It may be possible to resolve the matter by further elicitation of expert opinion or through further experimental study. If this does not provide a clear conclusion reasonably promptly, the OCRWM could address the problem by further redesigning the waste package to make it still more robust. There is ample time to do so, and the cost is minor, in the sense that it is unlikely to exceed something of the order of a few tenths of a mill per kilowatt-hour for the electricity produced by the nuclear fuel.[1]

The second of these issues is the disagreement between the DOE and the NRC staff on the risks from volcanic events. This disagreement has persisted for a considerable time, but remains unresolved. There is some suggestions that the preponderance of outside expert opinion favors the estimates presented in the OCRWM reports. For example, the disagreement is mentioned in the *Final Report of the Total System Performance Peer Review Panel* (February 11, 1999). While the Panel states that "the technical disagreements...need to be resolved," it expresses

[1]The total cost for waste package and drip shield fabrication is estimated to be $13.3 billion for 14,768 waste packages, i.e. $0.9 million per waste package [*Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program*, DOE/RW-0533 (May 2001), pp. 3-8 and A-1]. (This includes all waste packages estimated by 2040 for civilian and military wastes, but the possible differences in costs for these waste packages are ignored here because the majority of the waste packages are for civilian spent fuel.) On average, each civilian spent fuel waste package contains 8.4 MTHM with a burnup of 38.6 GWD/MTHM [see:*Yucca Mountain Science and Engineering Report*, DOE-RW-0539 (May 2001), Section 3.2] This amounts to an output of 2.5×10^9 kWh per waste package, and a total present waste package and drip shield fabrication cost of roughly $0.0004 per kWh.

concurrence with the OCRWM view that volcanism is "not an important contributor to doses" [pp. 9 and 112].
In a somewhat less direct indication of opinion, a U.S. Geological Survey report on Yucca Mountain expresses no particular concern about volcanic hazards at Yucca Mountain.[2] None of this constitutes an adequate resolution of the dispute concerning the volcanic risks at Yucca Mountain. However, it suggests that it is prudent to proceed with Yucca Mountain while the issue is being further addressed. At worst this would represent a wasted effort, because in the end the NRC holds a veto power over the start of repository construction and therefore must be satisfied as to repository safety.

In considering the previous two issues, it should be noted that the calculations reflected in the PSSE indicate that the repository will satisfy the EPA's already strict standards by a very large margin. Comparing to the 10,000-year dose limit of 15 mrem/yr, there is a calculated margin of over 100,000 if one ignores disruptive events and a margin of over 100 if the OCRWM calculations for disruptive events (primarily volcanic) are included. Thus, even were volcanic events more probable and potentially more severe than assumed in the PSSE, Yucca Mountain could still be a suitable site.

In my view, one further addition to the documentation would be useful: an explicit discussion of the probability of major mishaps. For purposes of such an analysis, I suggest including only individual doses that are above a reasonable *de minimis* threshold (say, greater than 1 mrem/yr or 10 mrem/yr)[3] and that add up to a reasonably high population dose (say, greater than 1000 rem/year).[4] It would be instructive to see the results of such an analysis summarized in a graph of the probability of occurrence vs. collective dose for the region above 1000 rem/yr. Volcanic events would presumably be included in this analysis. I infer from existing studies of sensitivity to parameter variations that the results would be quite reassuring. However, I think it would be useful to carry out and present the results of such an analysis, despite the large inherent uncertainties.

While a Presidential recommendation to authorize application for a construction license should not be made lightly, without strong scientific justification, it should be recognized that such an application does not represent a point of no return. Ample opportunities remain to modify or abandon the project if new scientific evidence were to dictate such a course. First, during the preparation of the application and during the NRC review, each of which will require several years, the proposed design will be finalized and undergo rigorous scrutiny, with always the possibility for modification. Second, before final closure of the repository there will be a long period (possibly well over 100 years) during which changes and even waste package removal would be possible.

In summary, I believe that the PSSE and supporting documents provide a more than adequate basis for finding that the Yucca Mountain site is suitable for development to the extent of preparing an application for construction authorization. Further study should be carried out during the extended time required for preparation of the application and for its examination by

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[2] *Yucca Mountain as a Radioactive-Waste Repository,* Circular 1184 (U.S. Geological Survey, 1999).
[3] The threshold requirement is motivated by earlier experience with the miniscule individual doses from carbon-14.
[4] A collective dose of 1000 rem corresponds to less than one eventual fatality, according to standard current estimates.

the NRC. But the prospects of a favorable outcome of the technical aspects of the process seem to me to be good.

Topic 2. If the Secretary finds that YM is likely to meet the required standards, he should recommend the site to the President with as forceful an endorsement as possible, for reasons discussed in my general comments (below).

Topic 3. I am aware of no valid reason why the President should not act positively upon a positive recommendation from the Secretary. There may be political reasons, but the stakes are too great to allow political difficulties to dissuade the Administration from pursuing a Yucca Mountain repository, if the scientific evidence suggests that it is technically sound and does not endanger human health or the environment.

C. GENERAL COMMENTS

The stringency of the EPA's standards for Yucca Mountain

It should be recognized that the levels of radiation risk being considered for Yucca Mountain, using the EPA's standards as a yardstick, are very low. In the regulations of 10 CFR 197, it is required that the dose to the "reasonably maximally exposed individual" be limited to 15 mrem/year over the next 10,000 years. Here is may be noted that:

(a) This dose, to the maximally exposed individual, is only about 5% of the natural radiation dose received by the average individual in the U.S. today.

(b) The annual dose of radiation from natural sources in the vicinity of Yucca Mountain exceeds the national average of 300 mrem by considerably more than 15 mrem, due primarily to higher levels of thorium-232 and potassium-40 in the soil and the high altitude. The excess is about 30 mrem in Las Vegas, 40 mrem in Amargosa Valley, and 90 mrem in Beatty.[5] Elsewhere, in the United States and in other countries, there are still bigger variations. As a society, and for the most part as individuals, we are indifferent to variations in natural radiation doses on the scale of 10 mrem/yr or 100 mrem/yr.

(c) Given the rate of scientific and medical advances, it is highly likely that there will be improved ways of preventing or curing cancer within decades or centuries --- almost certainly within the next 10,000 years. It is not certain that an incremental dose of 15 mrem/yr increases cancer risks, but all cancer risks are likely to be much reduced in 10,000 years, unless there is a collapse of civilization in the interim.

Dangers to future generations

The demanding plans for Yucca Mountain are motivated by a sense of responsibility to future generations. But the radiation standards are so stringent that they bear little relation to the real problems involved in fulfilling our moral obligations. These are serious obligations and we

[5] *Draft Environmental Impact Statement for a Geological Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, DOE-EIS-0250D (July 1999), p. 3-81.

should endeavor to meet them. The fundamental goal should be to pass on a world in which each succeeding generation has the opportunity for a quality of life that is as good or better than that enjoyed by the preceding generation. Important enabling factors include an environment that is stable or improving, ample material and cultural resources, and continued technical and scientific abilities. Meeting of this goal is seriously threatened by the following energy-related problems:

(1) Eventual fossil fuel shortages. It is likely that the world's supply of cheap fossil fuels will be consumed on a time scale of decades or centuries: first for oil, later for natural gas, and still later for coal. If this proves to be the case and if non-fossil alternatives are not promptly developed, the world could face extreme energy shortages with the attendant prospects of social disruption and even energy-related warfare.

(2) Global climate change. The present scientific consensus holds that greenhouse gases from the combustion of fossil fuels pose a major environmental threat. Even if one cannot be certain that this is correct, it is important to develop alternatives to fossil fuels.

It is to be noted that the dangers from fossil fuel shortages and global climate change may impact the world relatively soon, while those from nuclear wastes are almost certain to be delayed by thousands of years. Further, the scale of possible harm from these dangers is far greater than the scale of dangers from the wastes. These are not independent concerns, because nuclear power can help to replace fossil fuels. Together with conservation and renewable energy, nuclear energy can directly reduce the need for fossil fuels in electricity generation. Over a longer term, there can be further electrification of the energy economy, including transportation, using electricity produced from nuclear or renewable sources. But there is little chance of increasing the use of nuclear energy unless waste disposal is satisfactorily addressed. At the moment there is no viable alternative to Yucca Mountain for long-term U.S. nuclear waste disposal.

Given these circumstances, it would be unfortunate to allow Yucca Mountain to be derailed by concerns over minor eventualities. We want to be sure that there is virtually no chance of a major disaster from Yucca Mountain. Hence the suggestion (above) that the possibility of major mishaps be explicitly investigated. But assuming that the chances of such a mishap are found to be negligibly small — as I suspect is already implicit from existing calculations — then we should promptly develop the repository.

<u>The crucial role of the President and Congress</u>.

With the breakup of the Atomic Energy Commission, responsibility for our nuclear energy activities is shared by the DOE, EPA, and NRC. This has the advantage of avoiding some forms of conflict of interest and of precipitous action. It provides for cross-checks, by having important technical issues considered by more than one agency. However, it leaves no single agency with the role of balancing all the costs and benefits and of formulating a policy that takes into consideration the broad issues of the sort discussed in the previous section.

This responsibility falls upon the President and Congress. I urge that they meet this responsibility by moving ahead with Yucca Mountain, always subject to scientific confirmation of the safety of the repository design.

Sincerely

David Bodansky
Professor Emeritus of Physics